ERIGERON LONCHOPHYLLUS Hook. Dr. Blake[1] gives the range of this species as "Saskatchewan to British Columbia, Nevada, and Colorado." Prof. M. E. Peck has found it in Oregon, and last summer the author found it in an open boggy creek bottom near Tonasket, Okanogan County, *Thompson* 8665.

ERIGERON ACRIS L., var. ASTEROIDES (Andrzej.) DC. Dr. Blake gives the range for the species as follows: "Quebec to Alaska, southward to New Brunswick, Michigan, Colorado and Utah." Two widely distant places in this State add it to its flora; base of Mt. Angeles, *Thompson*, 7358 and *Fiker* 1079 from Okanogan County.

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THE SPORES OF THE GENUS LYCOPODIUM IN THE UNITED STATES AND CANADA[2]

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(Plates 275–277)

THE occurrence of certain *Lycopodium* spores as fossils in peat has led to the study of the modern spores of this genus in the United States and Canada. The study has shown that the various *distinct* species have characteristic spore types, which make their identification as fossils possible; also it has suggested the use of spores as another criterion of species and a method of determining phylogenetic relationships.

MATERIALS AND TECHNIQUE

The spores studied were secured from fresh mature specimens of most of the American species of *Lycopodium* as well as from herbarium specimens from various parts of the world. Many slides were made of spores of each species and from these typical examples were chosen. A slight variation in size, shape, and pattern is found among the spores of the same species, but this is due mostly to the age of the spores (maturity and storage), the size of the sporanges from which the spores were taken, and the treatment given in preparing them for study. The smallest sporanges of a strobilus often have what appear to be immature or abnormal spores. Severe treatment will often

[1] Contr. U. S. Nat. Herb. **25** (1925).

[2] Published with aid to RHODORA from the National Academy of Sciences.

collapse the spore or destroy its diagnostic characters so the preparation must be uniformly and carefully made.

It is possible to determine a number of *Lycopodium* species without subjecting the spores to any clearing process, but others (*L. Selago*, *L. lucidulum*, *L. annotinum*, *L. cernuum*, *L. obscurum*, *L. inundatum* and *L. alopecuroides*) have a material on the inside of the walls, which gives the appearance of papillation and must be removed in order that the species be definitely identified. The composition of this removable material has not been determined, but it may be a type of stored food. The following schedule was used in preparing the spores: in a drop of 10% potassium or sodium hydroxide on a slide the spores were boiled for ten seconds, then removed with a scalpel or pipette to distilled water in a watch glass, washed several times by decanting and renewing water, after which they were mounted in glycerine jelly. Stains, such as gentian violet or Sudan 111, may be used, or green, red, and yellow light filters may be used instead to aid in studying the exine features.

The spores were studied under a compound microscope, using a 3 x ocular and a 6mm. objective. The drawings were made with the aid of a camera lucida and show only surface features. The surface upon which the germinating slits are seen is called the apical surface and the basal surface is that opposite. Direct views of both basal and apical surfaces have been drawn and have proved adequate for comparison except in the apical-surface-views of *L. inundatum*, *L. alopecuroides* and *L. carolinianum*. These species have concave apical sides that could not be rendered very satisfactorily; however, the ornamentation has been correctly recorded.

DISCUSSION

By the type and ornamentation of *Lycopodium* spores it is not only possible to distinguish the various species, but also to group the North American forms into sections, which coincide with those that have been made on other morphological structures.

If the American and Canadian species of *Lycopodium* be grouped according to their gross morphological relationships the following three groups will be made: (1) species with a primitive strobilus having unspecialized green sporophylls (*L. Selago* and *L. lucidulum*); (2) species with a slightly to greatly advanced strobilus and slightly to greatly specialized sporophylls (*L. alopecuroides*, *L. inundatum* and

L. carolinianum); and (3) species with a distinct strobilus and highly specialized yellow, scale-like sporophylls (*L. cernuum*, *L. annotinum*, *L. obscurum*, *L. clavatum*, *L. complanatum*, *L. sabinaefolium* and *L. alpinum*). These progressive evolutionary movements have been discussed more fully by Schaffner,[1] and the present findings agree very closely with the line of development described by Dr. Schaffner. There is, however, one minor point of difference found when a study is made of the peduncled strobilus. This will be discussed under group three.

In the first group, composed of *L. Selago* and *L. lucidulum*, the spores are characteristically triangular with concave sides, when observed either on the apical or basal surface (see drawings). The spores of these species differ in size and quality of papillation. Usually *L. Selago* spores are about 5 mu larger in diameter than those of *L. lucidulum;* also, the papillation on the exine of the latter is finer. These spores must be treated as directed above or the material on the inside of the spore wall will appear as papillae masking those on the exine. In *L. Selago* these "false papillae" are usually quite regular while they are not always so in *L. lucidulum*. In an earlier paper[2] describing this group only the "false papillae" were described. With some practice it is possible to distinguish the two species without clearing the spores, but it is advisable to use a uniform technique. The drawings of these two species do not show the "false papillae."

Lycopodium inundatum, *L. alopecuroides*, and *L. carolinianum* compose the second group of Lycopodiums and, like the first, they have characteristic spores. The spores are larger than those of the other species. The germinating slits occur in a furrow that is unornamented. These three species appear to represent an ancient group. The probable antiquity of *L. carolinianum* has been pointed out.[3] *L. alopecuroides*[4] appears to be confined to the Atlantic Coastal Plain and *L. inundatum*, while widespread in boreal regions, is probably a more recent offshoot from the same stock.

Lycopodium carolinianum may be considered by some investigators as belonging to the next group, but though the sporophylls of this

[1] Schaffner, J. H. 1931. *Characteristic Examples of accumulative progressive evolutionary Movements.* Ohio Jour. Sci. **31**: 346–349.

[2] Wilson, L. R. 1932. *The Identity of Lycopodium porophilum.* Rhodora. **34**: 169–172.

[3] Fernald, M. L. Rhodora **33**: 46. 1931.

[4] *Lycopodium alopecuroides* is sometimes treated as a variety of *L. inundatum*, but the spore differences would indicate that they are distinct species.

species are yellow and highly specialized, the strobilus distinct upon a scaly peduncle, and the leaves of the stem of two types, the relationship suggested by the spores, the type of rootstock, and the solitary cone upon a peduncle are here considered more fundamental than those characters which would place the species in the next group.

The spores of The Atlantic Coastal Plain species have been referred to as having a size relationship; also the basal surface is found to be wavy-reticulate. In a fourth species (*L. cernuum*) the same wavy reticulation appears. The spore is not, however, nearly the size of those of the other species, but is the smallest of any belonging to the genus in this country or Canada. It would be assuming too much, so few species of the genus having been studied, to construct a phylogenetic series that might illustrate the relationship of one type of *Lycopodium* species to another. Probably the greatest obstacle is the fact that the genus is of such great age that the species living today may represent the ends of long lines of evolution upon widely divergent branches. It is, however, interesting to note the geographic and spore-type relationship of the Atlantic Coastal Plain species. Here we have an ancient physiographic province with a type of habitat that may be of similar great age, and a flora upon it that suggests antiquity. That the Atlantic Coastal Plain species of *Lycopodium* should show relationship by their spores is of considerable interest.

In the third group there are numerous spore types. In this respect it is unlike the others, for *L. cernuum*, *L. annotinum*, and *L. obscurum* appear to be less closely related to each other than are the species within each of the two previously discussed groups. *L. obscurum* spores are the nearest in type to those of *L. clavatum* and the *L. complanatum* group, but differ from them in having an extremely delicate reticulation on the apical surface and coarser reticulation on the basal surface. In other words they have two distinct types of reticulation, while the others have only one. The two last named forms appear to be related to one another if spore type is a criterion. *Lycopodium clavatum*, however, may be separated from the *L. complanatum* group by its smaller reticulation.

The spores of *L. complanatum*, *L. sabinaefolium*, and *L. alpinum* at first appeared to be distinguishable from one another by diameter and the extent to which the reticulation nears the junction of the germinating slits, but these characters apparently are not constant and one is inclined to go back to the suggestion of Underwood[1] and

[1] Underwood, L. M. 1882. Our Native Ferns and their Allies, ed. 2. pp. 118–119.

consider *L. alpinum* and *L. sabinaefolium* as forms of *L. complanatum*. If we interpret this condition of the spores as evidence for close relationship within the Lycopods, it is possible that in this section of the genus is a group of plants that are either extreme ecological forms or which have evolved only slightly along certain trends. Recent treatments would favor the latter possibility.[1]

Dr. Schaffner[2] considers the presence of a peduncle an advance over the sessile type of strobilus, which in all probability is a correct assumption. However, if the three species, *L. complanatum*, *L. sabinaefolium*, and *L. alpinum*, are studied it will be observed that though they are obviously related in their spores and foliage *L. complanatum* has a stout, scaly peduncle, *L. alpinum* has a leafy branch-like peduncle, and *L. sabinaefolium* is intermediate between the two, having a slender peduncle of varied length and with sparse spreading scales. It appears from this that the structure and length of the peduncle may be variable within a group. This is further emphasized in *L. clavatum* and its varieties, for here there is a range in length of the peduncle from less than two centimeters to more than fifteen. The habitat of the plant appears to have much to do with the length to which the peduncle will grow, for among those plants occurring at high altitudes or in the extreme north will be found these short-peduncled forms.

No distinction could be made between the spores of *L. complanatum*, *L. flabelliforme* and *L. tristachyum*. In Wisconsin these three forms merge into one another and appear to be ecologically controlled. Victorin[3] has suggested hybridization for the origin of many forms in this group, but this has never been demonstrated, and the difficulties which accompany the germinating of *Lycopodium* spores make such experimentation practically impossible.

The following synoptic key is given as a brief review of the spore characters, the order of species being based upon spore relationship and gross morphology, and is subject to revision as other species are studied.

[1] Through the kindness of Professor M. L. Fernald the writer has recently been able to examine many more spores of *Lycopodium alpinum*. Measurements have been made of these and graphed to show size as compared with *L. sabinaefolium* and *L. complanatum*. From this study it appears that the spores of *L. alpinum* are slightly different from the others. The details are being reserved for further study.

[2] Schaffner, J. H. l. c.

[3] Victorin, Frère Marie-. 1925. *Les Lycopodinées du Quebec.* Contrib. du Lab. de Bot. de l'Univ. de Montréal. No. 3. p. 77.

The writer wishes to express his appreciation to Dr. N. C. Fassett for his kindly criticism and interest and to Dr. G. S. Bryan for suggesting a terminology for spore characters.

KEY TO THE SPECIES OF LYCOPODIUM IN THE UNITED STATES AND CANADA

A. Spores distinctly triangular and sides concave when seen on the apical surface; basal surface papillate; sporophylls unspecialized; strobilus primitive; plants gemmiparous; stems procumbent or erect; leaves flattened or appressed, little specialized.....B.

B. Spores 32 mu or more in diameter; papillation of exine uniform, evenly distributed; leaves appressed or spreading, widest below the middle, margins entire; stems erect or slightly procumbent.....*L. Selago.*

B. Spores 30 mu or less in diameter; papillation of exine delicate, often indistinct, sometimes irregular in distribution; leaves spreading, widest above the middle, margins serrate or entire; stems procumbent .....*L. lucidulum.*

A. Spores triangular to round and sides convex when seen on the apical surface; basal surface reticulate; sporophylls slightly to greatly specialized; strobilus specialized; plants not gemmiparous; stems horizontal or erect; leaves flattened, incurved, spreading, appressed, fused, or reduced, little to greatly specialized.....C.

C. Spores 43 mu or more in diameter, the germinating slits in a furrow, reticulation on the basal surface wavy; sporophylls green or yellow, slightly to greatly specialized; strobilus distinct and solitary upon a leafy or scaly peduncle; rootstock superficial, creeping; no erect branches; leaves flat, spreading or incurved...D.

D. Apical surface of spores papillate; sporophylls green and but slightly specialized; peduncle leafy; stem-leaves nearly uniform in size.....E.

E. Apical surface of spores with ridge-like rows of papillae extending to the edge of the unornamented germinating furrow, where the papillae are larger and irregular; sporophylls very slightly broadened at the base.....*L. alopecuroides.*

E. Apical surface of the spores with uniformly distributed papillae except in the unornamented germinating furrow; sporophylls distinctly broadened at the base.....*L. inundatum.*

D. Apical surface of the spores not papillate; sporophylls yellow and greatly specialized; peduncle covered with small scale-like bracts; stem-leaves of two distinct sizes.....*L. carolinianum.*

C. Spores 36 mu or less in diameter, the germinating slits not in a furrow, reticulation on the basal surface angular or wavy; sporophylls yellow and greatly specialized; strobilus distinct, sessile or peduncled, one to several on a peduncle; rootstock subterranean or superficial with erect branches; leaves flat, incurved, appressed, fused, or reduced...F.

F. Diameter of the spores 23 mu or less, reticulation on the basal surface wavy, apical surface unornamented; strobilus sessile; sporophylls small and spinulose; leaves linear and incurved.....*L. cernuum.*

F. Diameter of the spores 28 mu or more, reticulation on the basal surface angular, apical surface unornamented or angular-reticulate; strobilus sessile or pedunculate; sporophylls large, not spinulose; leaves flat, incurved, appressed, or fused . . . G.

G. Spores unornamented on apical surface; strobilus sessile; leaves flat or appressed; rootstock superficial . . . . . *L. annotinum.*

G. Spores with angular reticulation on the apical surface; strobilus sessile or pedunculate; leaves flat, incurved, or fused; rootstock subterranean or superficial . . . H.

H. Reticulation on the apical surface finer than on the basal surface of the spores; leaves flat or incurved; rootstock subterranean; upright branches tree-like . . . . . *L. obscurum.*

H. Reticulation on the apical surface of the spores of the same quality as on the basal surface; strobilus sessile or pedunculate; leaves incurved or fused; rootstock subterranean or superficial; upright branches spreading or tree-like . . . I.

I. Ridges of the reticulation appearing on the equator numbering 35 or more, on the apical surface the reticulation usually extending to the junction of the germinating slits; leaves incurved; rootstock superficial; upright branches two or three times divided but not tree-like . . . . . *L. clavatum.*

I. Ridges of the reticulation appearing on the equator numbering 30 or less, on the apical surface the reticulation usually not extending to the junction of the germinating slits; leaves fused at the bases and reduced; rootstock subterranean or superficial; upright branches usually tree-like . . . . . *L. complanatum* group.

Explanation of Plates 275–277

Plate 275. Spores of *Lycopodium Selago* L., *L. lucidulum* Michx., *L. annotinum* L. and *L. cernuum* L.; figs. at left basal view, at right apical view.

Plate 276. Spores of *L. inundatum* L., *L. alopecuroides* L. and *L. carolinianum* L.; figs. at left basal view, at right apical view.

Plate 277. Spores of *L. obscurum* L., *L. clavatum* L. and *L. complanatum* L.; figs. at left basal view, at right apical view.

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SOME TRANSFERS IN DIGITARIA AND PASPALUM

M. L. Fernald

Digitaria filiformis (L.) Koeler, var. **villosa** (Walt.), comb. nov. *Syntherisma villosum* Walt. Fl. Car. 77 (1788). *D. villosa* (Walt.) Pers. Syn. i. 85 (1805).